SCOTTISH PLANT BREEDING STATION

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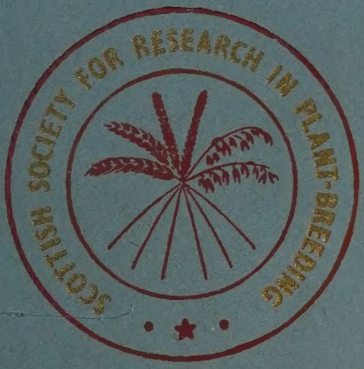

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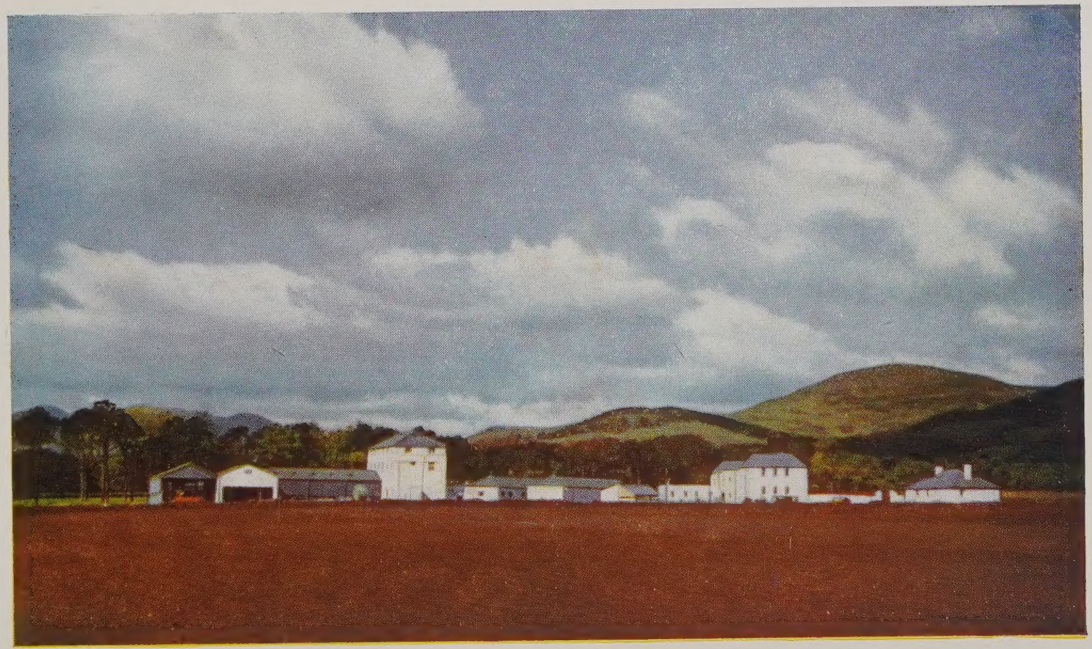

D. A. Govier

PENTLANDFIELD SITE

SCOTTISH PLANT BREEDING STATION

OPENING

OF

PENTLANDFIELD

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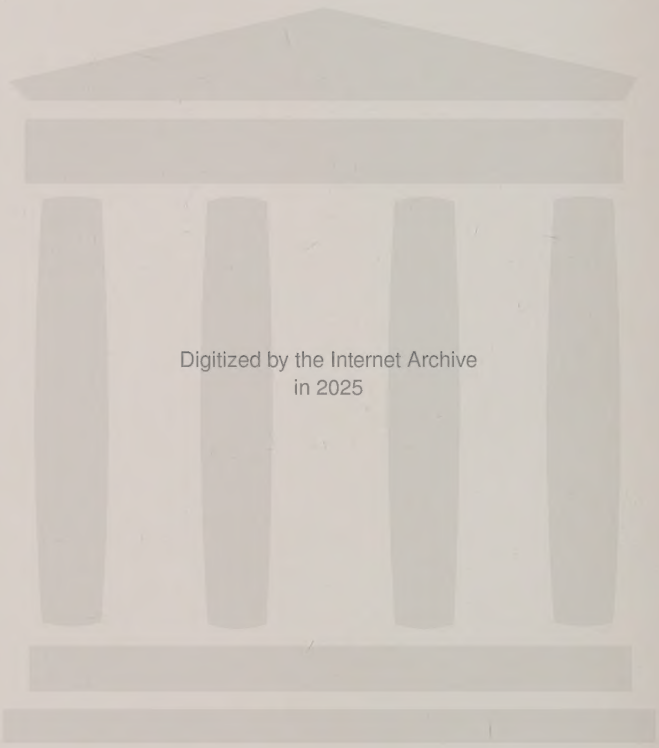

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FOREWORD

It is thirty-five years since the Scottish Plant Breeding Station came into being at Craigs House, Corstorphine, and the removal in November of last year to the new premises at Pentlandfield brings to an end a chapter in the history of the Station. Inevitably with the cessation of the association with Corstorphine memories of the beginnings and subsequent developments are reviewed, and it would seem to be a natural and favourable point at which to reflect on the kind of work that has been done in the light of the original objectives.

In the Rules published in 1920, it is stated that the operations of the Society are to be exclusively scientific, and to have as their objects the promotion of agriculture, arboriculture and horticulture. Owing to the very limited resources then available at Corstorphine it was obviously impossible to launch out on such a comprehensive programme, and not unnaturally the emphasis was primarily placed on agriculture. And so the position remained until during the War some attention was given to strains of vegetables suitable for allotment holders, and more recently a member of the Station's staff started to examine the variational situation in the birch populations of Britain. No attempt, however, has been made to enter the field of sylvicultural research, which is now dealt with by the Forestry Commission. Horticulture can also safely be deleted from the list of objectives as it is specially catered for at the new Scottish Horticultural Research Institute.

The Station's current operations are organised in five Sections, each Section representing a crop, or class of crop, and each being under the control of a specialist group of workers. These five Sections are as follows: (1) *Cereals*, now confined to oats; (2) *Herbage Plants and Genecology*, a Section concerned with the breeding of arable-land grasses as well as with the study of the components of the vegetation of uncultivated grazings, hence the inclusion of the subject genecology in this Section's title; (3) *Potatoes*, for convenience the work of this Section is conducted under two heads, (*a*) the breeding of new varieties, and (*b*) the study of the virus diseases

of the potato; (4) *Root crops and other Brassicas;* and (5) *Sugar Beet.*

On the occasion of this, the first Report from Pentlandfield, it is felt that a general picture broadly illustrating the activities and progress of these various Sections would be more welcome than the customary somewhat detailed report of the past year's work. Accordingly, certain aspects of research done over a period of years are shortly reviewed in the hope that they will be sufficient to indicate the nature and scope of the Station's investigations, and how far the original terms of reference have received practical expression.

It is also of interest at this time to consider the present position at Pentlandfield with reference to finance and the Station's autonomy, for very substantial State aid in respect of Capital and Maintenance grants has been necessary to provide the greatly improved facilities. It is perhaps not always remembered, however, that even from its inception the Station has been in receipt of financial assistance from the State. In the early years, though the grants were only a fraction of what they are to-day, they nevertheless represented as much as 33 per cent of the Society's total income. As a consequence of the move to Pentlandfield the most significant change in the Society's circumstances is that to-day virtually the whole of the Society's income derives from Government sources because the bulk of the Society's capital has been required to augment the State's contribution towards the cost of erecting the new buildings. This time, under the new set-up there has been no land purchase involved, as was the case at Craigs House, for by arrangement with the Edinburgh Centre of Rural Economy the building site (approximately 5 acres) is feued to the Society and the experimental area (approximately 50 acres) is held on what in effect amounts to a "permanent tenancy," the Society paying the Edinburgh Centre of Rural Economy by way of rent a fluctuating annual contribution or rate basically assessed on the acreage occupied.

Despite these changes in the financial position of the Society and in the conditions of land tenure, the Scottish Plant Breeding Station retains its identity and will continue to function as an autonomous unit managed by a Board of Directors, who, with the exception of the four nominees of the Department of Agriculture for Scotland, are freely chosen from the Society's membership. It is, however, only to be expected, and indeed

inevitable in the circumstances, that Government should have some control over the Station's activities, but apart from the maintenance expenditure requiring the approval of the Department of Agriculture for Scotland, and the scrutiny of the research programme by the Department in consultation with the Agricultural Research Council, the Society is free to manage its own affairs. In fact, the Plant Breeding Station is operated by a partnership of the Agricultural Industry, the Department of Agriculture for Scotland and the Agricultural Research Council; a happy combination in which the State has an obligation to the consuming public as much as to the industry itself.

J. W. G.

A SCOTTISH STATION FOR RESEARCH IN PLANT BREEDING

By Sir John H. Milne Home, *Chairman*

It would be difficult for anyone to answer the question, When did research in plant breeding begin? The gradual improvement of the cereals and other plants grown for human and animal food has gone on for centuries. It is a matter of opinion as to when experiment, reinforced by science, reached a point at which the term "research" could correctly be applied. Only within the present century has research in its present-day meaning been truly evolved. Early methods followed in the seventeenth and subsequent centuries consisted in the selection by eye of specially promising plants, from which seed was collected and grown on. Improvement was inevitably very slow, and these methods must sometimes have gone on to wrong lines. Nevertheless, it was by patient observation and trial of this kind that the well-known varieties of oats and barley were evolved in Scotland down to the nineteenth century. At the time that the establishment of a Plant Breeding Station in Scotland was first contemplated the Swedish station at Svälof was already well known, and had been visited by some. The work done at Rothamsted by Lawes and Gilbert, and later carried on by Russell, had a profound influence on the more advanced agriculture of the time. It was, of course, more related to cropping methods and soil research than to plant breeding. The perils which the country had just come through and its dependence upon imported food had been deeply impressed upon more thoughtful persons. Increased production per acre from our limited area of arable land was seen to be of great importance.

Looking back to the time thirty-five years ago when a group of enthusiasts first thought of establishing a Plant Breeding Station for research in Scotland, it is not easy to define the exact starting-point. Those of us who are old enough to remember Dr Charles Douglas of Auchlochan will most likely attribute to him the largest share of credit for the project.

Mr James Elder was another leader. The Directors of the Highland and Agricultural Society were strong supporters, and the earliest meetings when the Plant Breeding Society was first constituted were held in the Society's rooms, then at George IV. Bridge. At those early meetings the words "exclusively scientific" in the original Rules were the subject of a good deal of discussion. It was felt that while it must be made clear the Society was not a trading body, it was, nevertheless, desired that the objective of the Director and his staff should be the application of plant breeding research to certain definite agricultural problems and needs. This was not intended to restrict the Director from a measure of fundamental research which must be necessary in the study of new and varying problems. It can be claimed that throughout the Society's history under successive Directors a fair balance has been maintained, and the Society has been able to earn and retain the confidence of its members, and of the agricultural industry as a whole.

It is fortunate that in Britain research, trial and experiment in the agricultural field has proceeded upon sound and relatively cautious lines, thereby avoiding large-scale fiascos such as have taken place in other countries in recent years. These failures have in nearly every instance been due to attempting to apply some particular scientific theory untested by experience. To attempt a quick spectacular result, rather than to follow up a research discovery by careful trial and testing on a level of agricultural practice, is tempting though seldom rewarding. Although this is hardly the place to go into great detail as to the various lines on which research has developed over the Society's life it is perhaps permissible to refer specially to one branch—viz., the grasses and herbage. These had only a very small share of attention in the early years, but have developed to a marked degree to-day. The Station has in many ways developed pioneer work in this sphere. Increasing emphasis is being laid in Government policy on the added fertility of pastures, temporary and permanent, and consequent increased carrying capacity for both sheep and cattle. While good pasture management and manuring are important, the species and varieties of herbage are now realised to be of equal importance. This is particularly true of the upland marginal and hill pastures where there is the greatest scope for upgrading. Ploughing of such lands is

rarely possible, but on the greater part of these areas improvement of the natural herbage by encouragement of the more valuable species is the obvious policy to follow. This in turn leads to the need for special study of the hill species of which we meanwhile know relatively little, and also of local variations within species.

It must always be a matter of difficulty to decide for how long the Society should retain entire control of new varieties and at what point these products should be issued to the seed trade and to farmers. This matter has had very close attention recently and it is thought that the arrangements now made and which have been described to members will work fairly and with satisfaction.

Members' subscriptions are to-day little more than token contributions forming but a small part of the Society's income. This does not mean that any member should feel on that account he has no share in the guidance of policy. It is essential for the vigour and welfare of the Society that it should have the widest possible contacts, and that the Board of Directors should, so to speak, have their fingers on the agricultural pulse of the day. The Director and his staff will always need to be made aware and to be kept informed of all plant breeding problems whether relating to one particular crop, or in the wider scope of national policy. The Board of Directors over the years has included many men notable in the agricultural sphere and it is to be hoped this will always be so. Younger men with fresh minds will be wanted to replace those who have, with the passing years, to withdraw from the tasks to which they have set their hands. With the increasing interest shown by young farmers in agricultural science and research, there is little doubt that future support for the Society will not be lacking.

The methods of bringing results to the farmer have been already briefly referred to. It is important that this be done effectively and with as little delay as possible. A Research Station is not an advisory body, although any member can write to the Director on some personal problem and be assured of a considered reply. The normal channel for sending out ascertained results is through the Agricultural Colleges. These have the means through their County Advisory Officers of keeping in touch with all farmers in their area, more particularly the most progressive and enterprising men. The

Colleges have, for example, been ready to help in the management and supervision of Oat Selection Centres. It is they, through their knowledge of varying local conditions, who can best ensure the successful application of research findings. Members of the Society have the opportunity, through the Annual Reports and in other ways, of keeping abreast of research progress. If any new product appears to have an application to a particular locality or district, there arises an opportunity for full discussion with the local advisory officer, and among the farming community.

At this milestone in the Society's history, it is appropriate to look back over the years that have gone. But the present has its problems which demand attention and the future has to be planned. Agricultural practice, education and research have all made rapid progress since this Society was first established. It would be rash to set bounds on the rate of future progress and discovery in these fields.

AGRICULTURAL RESEARCH IN SCOTLAND

Contributed for the Department of Agriculture for Scotland

The Secretary of State for Scotland, through the Department of Agriculture for Scotland, is responsible for the general administration of agricultural research in Scotland. The policy of the Department has been to organise agricultural research by subjects and to establish and develop research institutes for the study of these subjects. These institutes, which receive State funds through the Department for both capital and maintenance purposes, are the Rowett Research Institute for Animal Nutrition (established in 1913), the Scottish Society for Research in Plant Breeding (1920), the Animal Diseases Research Institute (1920), the Hannah Dairy Research Institute (1927), the Macaulay Institute for Soil Research (1930), the National Institute of Agricultural Engineering Scottish Station (1949), the Scottish Horticultural Research Institute (1953) and the Hill Farming Research Organisation (1954). Considerable amounts were raised locally for the establishment of the earlier institutes. For instance, the Scottish Society for Research in Plant Breeding raised £22,500 and received a similar amount from State funds. The importance of research to the agricultural industry led to the State providing more and more of the expenditure of the institutes until now the position is that almost 100 per cent of all approved expenditure is met by the State.

In the discharge of their responsibility for the promotion and development of agricultural research in Scotland the Department seek and obtain the advice from the scientific standpoint of the Agricultural Research Council which was set up in 1931. In particular, the Department are advised by the Council in regard to the programmes of work of each institute, the appointment and promotion of scientific staff and the provision of scientific apparatus and equipment. The Council themselves are responsible for the co-ordination of all agricultural research in the United Kingdom and for the administration of its own institutes, two of which have their headquarters in Edinburgh—namely, the Animal Breeding Research Organisation and the Poultry Research Centre. A more comprehensive account of the activities of the Agricultural Research Council is given in the following section of this report.

Mention should be made of two other centres of research on a limited scale within the Department itself. The first of these is the Seed Testing, Plant Registration and Plant Pathology Station at Corstorphine, Edinburgh, a station which, though primarily concerned with enabling the Department to exercise certain statutory functions, carries out crop plant research. The second is the Farm Economics Branch of the Department which undertakes a certain amount of research in the field of agricultural economics and collaborates closely with the specialist advisory departments in agricultural economics at the Colleges of Agriculture.

Until the move to Pentlandfield at the end of last year the Plant Breeding Station and the Seed Testing, Plant Registration and Plant Pathology Station were neighbours at Corstorphine, and it is interesting to record that prior to the establishment of either, the sponsors of the Plant Breeding Station expressed the hope that in due course two such Stations would play complementary rôles in matters concerning crop plant production. These hopes have been amply realised, for between the two Stations there has developed a very close and harmonious association. The Director of the Department's Station became a Government nominated member of the Society's Board, and the Director of the Scottish Plant Breeding Station is a member of the Standing Committee of Management of the Scottish Plant Registration Station.

In 1941 the Secretary of State set up a Scottish Agricultural Improvement Council which at present is composed of the Directors of all the research institutes in Scotland, the Principals of the three Agricultural Colleges and farmers. This Council is charged with the duties of devising methods for seeing that promising results of research are applied as rapidly as possible to the problems of agriculture and horticulture and are incorporated in ordinary farming practice and of advising from time to time concerning agricultural and horticultural problems which appear to require scientific investigation. The composition of the Council ensures that the problems of the farmers are brought to the notice of the research worker through the farming and College representatives while the results of the research worker are conveyed to the farmer through the College Advisory Services. A Joint Committee of the two Improvement Councils—for Scotland and for England and Wales—and of the Agricultural Research Council deals with matters of common interest to all three bodies.

THE CO-ORDINATION OF STATE-AIDED AGRICULTURAL RESEARCH

Contributed for the Agricultural Research Council

The Agricultural Research Council neither supports the Scottish Plant Breeding Station financially nor prescribes its activities, but is responsible for advising the Department of Agriculture for Scotland on the financial provision to be made for its maintenance and on other matters affecting its research programme and scientific staff. In order to discharge that responsibility the Council must have a detailed knowledge of the Station's programme, staff, facilities and achievements which can only be obtained by close and frequent contacts. Consequently the Council's relations with the Station are intimate though indirect.

The Council's responsibility in this respect is part of its wider responsibility for co-ordinating State-aided agricultural research throughout Great Britain—a function which must not be confused with central direction of research which the Council does not attempt or believe in. Agricultural progress depends on research in many different sciences, carried out in many different places under diverse controlling authorities. There are, for instance, no less than twenty Agricultural Research Institutes in Britain each of which, like the Scottish Plant Breeding Station, has its own Governing Body and manages its own affairs though largely dependent on money provided by the State. Each has a particular contribution to make, and an individuality, developed out of its history, traditions and special fields of interest, which is a valuable asset to be preserved. Yet it is necessary that these twenty separate organisations, with others of a different kind, should work collectively as an integrated Agricultural Research Service; because only so can the available resources in money and scientific manpower be distributed to the best advantage.

Experience has shown that the advantages of a co-ordinated Service can be obtained without sacrifice of individuality or initiative if guidance can be provided on the broad lines of research policy. The Council's aim is therefore to assess the relative urgency of the many scientific problems that confront

agriculture and to provide the necessary guidance in the light of its findings. Surveying the whole field of agricultural research, the Council can, for example, give warning if there is any wasteful overlapping of effort, or encourage new research if there are gaps in the national programme. It can also help to preserve a desirable balance between directly applied research and the search for new knowledge required to keep applied research alive. This indeed is one of its most important functions and one which brings it into close association with the Universities as well as the Research Institutes.

The Agricultural Research Council itself is an honorary body appointed by, and responsible to, a Committee of the Privy Council of which the Lord President of the Council is Chairman. Its fifteen members are chosen for their knowledge of agriculture or of one of the sciences bearing on agriculture, the majority being eminent scientists who are appointed with the advice of the President of the Royal Society. Each retires after five years' service so that the composition of the Council is continually renewed.

In order to review all activities in its wide field the Council has set up a system of Standing Committees, Technical Committees and Conferences on which other scientists and persons of special knowledge are invited to serve. These bodies keep in touch with progress in the major branches of research or in specific subjects and assist the Council in studies of detail. The Council also employs a staff under the Secretary to implement its policy and carry on daily business.

For helpful relations with a Research Institute such as the Scottish Plant Breeding Station the first requirement is that the Agricultural Research Council must be fully and continuously informed about research in progress. It receives annual programmes and reports through the Department of Agriculture for Scotland, but does not rely on these alone. At intervals of not more than five years the Council appoints a small group of its members and other scientists to visit the Station and meet the Director and staff. This group acquaints itself thoroughly with the work going on in the various departments, discussing with each worker his particular problems and the direction that his work seems likely to take in the near future. It also invites the Director's views about the broad outlines of the programme in hand and the adequacy of staff and equipment to carry it out.

Between these official visits, which are made with the full concurrence of the Department of Agriculture and the Board of Directors of the Station, individual members of the Council and of the Council's staff have frequent opportunities for less formal contacts with the research workers, which help to keep their knowledge up to date. Thus, annual reports and programmes are read by the appropriate Standing Committee of the Council in the light of personal knowledge of the matters recorded in them. Annual programmes usually differ little in broad outlines from those discussed with the Director by the visiting group ; but changes of detail or of emphasis may be brought about by new discoveries or by staff changes, and these are readily appreciated by those in touch with the work.

The Council's information is especially valuable because it can be related to similar knowledge of what is going on elsewhere. It is put to use each year when the Director of the Station with the approval of his Board of Directors submits estimates of maintenance costs to the Department of Agriculture and the Council. In advising the Department on the provision of funds, the Council has more to consider than the intrinsic merits of the programme for which they are needed. There are three State-aided plant breeding stations in Britain, each catering especially for the needs of its own region but producing new field-crop varieties that may be useful in other parts of the country and also contributing to the pool of scientific knowledge relating to crop breeding. Several other Research Institutes have departments breeding horticultural crops and likewise producing fundamental genetical information as well. Altogether thirteen Institutes working on plants and soils are engaged in studies of crop production, of which breeding is only one aspect. In addition, the pool of knowledge is fed from numerous University Departments investigating problems in plant genetics, physiology or pathology. The resources available for all this research are not unlimited. The Council must therefore judge the Station's proposals by the extent to which they fit into the national pattern of research requirements, not only in plant breeding but over the whole field of agriculture, and give its advice accordingly.

The Council's responsibility does not end with advising on the annual estimates. The course of research is always un-

predictable, and sometimes unanticipated needs arise for change of emphasis in the programme or for special equipment. An institute's programme is also liable at any time to be affected by staff changes. Appointments, promotions and other matters affecting the scientific staff are among the subjects upon which the Council's advice is sought as occasion arises.

The scientific staff of the Scottish Plant Breeding Station are recruited and employed directly by the Scottish Society for Research in Plant Breeding, just as the staffs of other Agricultural Research Institutes are employed by the particular Institutes to which they belong. The Council's advice, however, is sought and given with the object of ensuring that all scientists in the agricultural research service enjoy similar conditions of employment and similar emoluments in relation to their qualifications, abilities and experience.

It is often desirable for research workers to visit foreign institutes where work similar to their own is in progress. By advising in this matter also, the Council is able to allot the limited funds available for travel abroad so that the different branches of research, and as far as possible the various Institutes, get appropriate shares.

Another way in which the Council co-ordinates research is by bringing together small groups of workers from different places who have common interests and are investigating similar or closely related problems. For example, quite recently potato breeders from several Institutes including the Scottish Plant Breeding Station met at the Council's invitation to examine together the direction that their work has been taking and discuss what developments might be desirable. A little before that a representative of the Station took part in talks on the testing of grass strains.

Subject meetings of this kind are not confined to members of the Agricultural Research Institutes. Members of the Staffs of Universities and Agricultural Colleges and of the Agricultural Advisory Services are also invited when their interests are relevant. There is a minimum of formality so that the research workers can discuss their problems freely. They exchange information about what they are doing, and often decide among themselves how work in their special field can best be distributed without undue overlap. The Council

notes the conclusions reached and if its assistance is needed to facilitate progress it takes whatever action seems most appropriate in the light of the workers' opinions.

The Agricultural Research Council has other duties beside the scientific supervision of the research institutes. Among them, it has to maintain liaison with the Government Agricultural Departments—the Ministry of Agriculture, Fisheries and Food and the Department of Agriculture for Scotland—who are concerned with agricultural policy and development. This it does largely through the two Agricultural Improvement Councils, one for Scotland and one for England and Wales. The Improvement Councils advise the Research Council about problems which they think require investigation, and in the reverse direction the Research Council passes to them the results of research which are ripe for development and application to farming practice. A Joint Committee of the three Councils hastens consultation and action on matters of common interest and thus provides a close link between the research and advisory services.

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THE MAIN BUILDING

By permission of 'The Farming News']

THE COMMON ROOM

A Corner of the Library

By permission of "The Lancet."

Pathology Laboratory, Pentlandfield

By permission of 'The Farming News']

CYTOLOGY LABORATORY, PENTLANDFIELD

GREENHOUSES AND LABORATORY BUILDING

THE SCOTTISH PLANT BREEDING STATION

Craigs House, 1921-1954

In the Society's first Annual Report published in 1922 reference is made to the receipt of a collection of breeding material from the representatives of the late Dr J. H. Wilson of St Andrews. This collection, comprising selections and named varieties of oats, two hundred or more strains of potato, and a number of strains of swede, made it possible to make an immediate start with these three crops. In the case of oats the initial aim was to obtain improved varieties of the Potato, Sandy, and Tam Finlay types which suggests that the intention was to cater for the least favourable environments ; the potato programme was to take into account the raising of commercial varieties resistant to blight and wart disease ; while classification of varieties and an emphasis on feeding value formed the basis of the swede programme. By 1922 work with herbage plants was also visualised and the question of collecting material had been given some consideration. It is of interest to view subsequent developments in the light of these early proposals and to note changes of emphasis during the course of the years.

Cereals.—By 1926 twenty-six oat selections were found to be breeding true. These were mainly of the Potato and Sandy types and were intended for growing in districts where the old-established hardy varieties were normally grown. Performance tests had still to be done and it was not until 1930 that the first new variety, a particularly stiff-strawed Potato type, received the name of Elder and was introduced to the market. Two years later another variety having many of the characteristics of the old Sandy oat was registered by the Department of Agriculture for Scotland under the name of Bell. This variety, because of its earlier ripening, relatively good yield of grain and quality of straw, was intended as a substitute for Sandy, and to-day it is still gaining ground in the areas of low soil fertility and high rainfall in the West of Scotland. About this time increasing attention was being devoted to oats of milling quality, for with the rapid rise of mechanisation and the consequent decrease in the need for horse corn it was felt that

many a grower would prefer the kind of oat which would give him at least an opportunity of entering the milling market. Early Miller registered by the Department in 1934 reflected this trend. Since the war two further varieties have been named, Craigs Afterlea, an early oat for very high soil fertility conditions, and Albyn Donside, an early short-strawed Potato type.

With perhaps the exception of Early Miller the above varieties can best be described as falling within the category of special purpose oats. It is now regarded as desirable to pay rather more attention than hitherto to the production of general purpose types, which will give returns under a wider range of environments, a feature possessed in relatively high degree by some of the recent introductions from Scandinavia.

Bearing in mind the diversified environment of Scotland and at the same time the desirability of finding general purpose types while not neglecting special purpose ones, two selection centres were established in 1953, one in Inverness-shire and the other in Argyll. These two centres together with Pentlandfield represent three markedly different environmental areas and by using them for both the work of initial selection and for trials of fixed material, it should be possible to combine the breeding of specially adapted regional types with the discovery of varieties of wider environmental tolerance.

Although in the early years the work of the Cereal Section was confined to the oat as it is again to-day, some attention was given to other crops during the intervening period. For instance, preliminary work with wheat and barley was started in 1930 and after the outbreak of war in 1939 field beans and linseed were added to the list. The result was that the Station introduced in 1943 Scottish Iron III., a variety of wheat which found a ready market until about 1950, after which it was withdrawn. Also in 1943 Craigs Triumph barley was first offered for sale, and three years later a bean variety, subsequently named Albyn Tick, was put on the market. With the exception of these relatively minor diversions, the cereal programme has undergone comparatively little change from the time of its inception: the improvement of the oat crop was originally and still is the primary objective.

Herbage Plants and Genecology.—As far as the cereal programme is concerned it will have been noticed that economic considerations rather than circumstances arising as a result of

developments within the programme itself have been responsible for the changes in emphasis; on the other hand, the practical objectives of the herbage plant programme have gradually evolved during the course of, and under the influence of ideas derived from, work of an exploratory nature. This is understandable when it is remembered that the investigations started from scratch as it were, for at that time little relevant information was available. It is, therefore, not very surprising to find that since the provisional scheme of work was first formulated, the herbage investigations have been concerned with some problems which could not then have been foreseen. The original proposals were stated in general terms and gave first priority to the improvement of Perennial Ryegrass, Cocksfoot, Timothy and Wild White Clover, while the fescues were to receive attention as opportunity arose.

In the initial stages, during the time that breeding material was being accumulated, work on general techniques was proceeding and a start was made to study the pollination and conditions of fertilisation in the more important agricultural grasses. The next development was an investigation of the interrelationships and origins of species and intra-specific races, Timothy being chosen for this purpose. This type of study later became widely known under the title of "Experimental Taxonomy."

In due course a fairly representative collection of perennial ryegrasses became available for examination, and the exceptional leafiness and peculiar growth-habits of certain populations from uncultivated localities attracted attention, and invited speculation as to how such characteristics had been acquired. There followed a long series of genecological studies primarily concerned with the evolutionary aspects of intra-specific variation that have produced new facts and theories many of which bear upon the major problems of plant distribution, classification and utilisation. At the present time these investigations, interrupted by the war, are once again being actively pursued, special attention being devoted to the problems involved in bringing about a closer integration of genecological and ecological concepts bearing upon the description and classification of vegetation.

The striking difference between the "wild" perennial ryegrasses and the types in general commercial use encouraged the belief that it was only a matter of time before the "com-

mercial" strains would be replaced by leafy "indigenous" ones. However, these forecasts have turned out, in some instances at any rate, to be only partially correct and for a very good reason. For instance, the first strain of perennial ryegrass raised at the Station from "wild" material was a particularly leafy and, as is so frequently the case with such strains, late-flowering one, but despite its lateness it looked very superior to its "commercial" control when compared in a field trial on low fertility land. However, under liberal manuring the appearance of the control was so improved and its spring production so very much greater than this "indigenous" strain that it was obvious the two strains served two quite distinct purposes and therefore were not strictly comparable.

Though Cocksfoot was among the first of the grasses to undergo preliminary examination at the Station a number of years were to elapse before it reached the breeding programme. Its eventual entry was a result of the Station's attention being drawn to the detrimental influence upon the survival of perennial ryegrass in sheep pastures of some of the recently introduced strains of Cocksfoot, a defect presumed to be the result of selective grazing. It was therefore proposed that the Station should aim at producing an early cocksfoot of palatability more akin to that of ryegrass. On the assumptions that a soft-leaved cocksfoot was needed and that woodland populations were most likely to provide the desired type, a number of samples were collected from the "wild." A woodland population from Perthshire afforded plants of the leaf-type wanted but hardly sufficiently early. However, selection from the early end of the range of variation ultimately yielded a strain that was both reasonably early and soft-leaved, and this strain was put on the market under the name of Scotia Cocksfoot.

Since the Station had by now a number of grass strains awaiting trial and as the improvement of hill land had for some time been contemplated, it was decided to combine the strain trials with direct reseeding experiments.

Though these upland trials merely confirmed the results of other reseeding experiments they did emphasise certain points : (1) the comparatively poor performance of early strains, the lateness of "indigenous" strains, and the negligible winter production of all strains under moderate manurial treatment ;

and (2) unless provision was made to supplement the supply of winter feed on breeding farms, reseeding of hill land created more problems than it solved.

It was, therefore, thought advisable to approach the problems of hill lands from another angle. Bearing in mind the phenomenally high protein production obtained in the earlier series of strain trials as a result of the lavish use of applied nitrogen it was felt that if similar treatment were to be given to reseeded areas the contrast, both in quality and quantity, between reseeded and untreated herbage would be markedly increased. If then, instead of using reseeded swards for whole-time grazing they were to be used in conjunction with relatively low quality rough grazings, the contributions of small acreages of treated grass would have greater significance. Field trials indicated that the complementary use of such contrasting vegetations can be modified to meet a number of practical situations and thus the emphasis was transferred from the replacement of natural vegetation to the problem of how best to use it. It is obvious then that it is essential to acquire knowledge of the potentialities and possibilities of the vegetation of natural grazings and this suggests that the plants of these grazings are no less worthy of intensive study than those of arable land. This view receives practical expression in the genecological studies of the populations and community structure of natural vegetation now in progress and thus the occasion has arisen to include the fine-leaved fescues in the Station's programme of research, and so to implement the second proposal of the provisional scheme of work formulated in 1922. Quite the most striking feature of these past thirty-three years has been the progressive realisation of the potentialities of grass as an arable crop: that permanent grass is also a crop with potentialities there would seem to be little doubt, though in the face of the more pressing claims of arable grass it has tended to be overlooked.

Root Crops.—As already indicated, changes in the herbage plant programme have been mainly made in response to developments within the programme itself. The picture, however, is rather different in the case of root crops, for here an agricultural situation has been gradually evolving that to some extent threatens the future of the swede crop, upon which the investigations at the Plant Breeding Station were originally centred. In 1913 the turnip and swede crops together occupied 432,000 acres in Scotland, or 13 per cent of

the area under arable crops. By 1952 only 8·8 per cent was cropped with " turnips " and this was barely 281,000 acres. In these forty years the percentage has been declining slowly but steadily, uninfluenced by either the great reduction in the arable acreage between the wars, or the reploughing during the second. Nevertheless, 281,000 acres is still a considerable amount of arable land. Among competitive crops sugar beet occupied 10,000 acres in 1952, and mangolds, which have increased in the sugar beet districts, 8,000. Kales were first mentioned in the Agricultural Returns in 1938. Prior to that date 4,000-5,000 acres were cropped with cabbage for stock feeding, but now the cabbage or kale crop occupies about 14,000 acres. The acreage of rape before the last war fluctuated between 4,000 and 17,000, but in 1944 it stood at 35,000, declining in 1952 to 27,000. The waning popularity of the swede and turnip crop is generally attributed to high labour costs and the prevalence of clubroot. None of the other crops mentioned above appears likely to be able to replace the " turnip " in the foreseeable future, yet for certain purposes and in certain districts kales are gaining ground. But probably the greater competition comes from the grass crop and this may well be intensified as past unfortunate experiences of silage-making are forgotten, though grass silage is not the complete answer to the problem of winter feed. Since the swede has until now dominated the root crop programme this trend must be taken into account, though it is only natural that when dealing with biennial plants with relatively long intervals between generations the disturbance of an established scheme of work cannot lightly be contemplated.

In 1922 investigations were started on both swedes and common turnips, but the latter were discontinued on account of climatic obstacles to propagation. The first task was to investigate causes of lack of uniformity in crops of swedes. Characters were checked by their expression in self-fertilised progenies and descendant lines. Environment was found to be responsible for much variability in size and shape of individual roots, heredity for certain foliage details and recessive skin colours, while seed admixture accounted for some extreme off-types such as the " bulbless " rogue, which sometimes causes serious loss. These rogues are usually true-breeding rape, but occasionally a hybrid of swede × rape.

The swede plants being, with rare exception, capable of self-

fertilisation, the idea of a strain rendered uniform and true breeding by continuous selfing and selection of single plants appealed to plant breeders in the 'twenties. The method was given a comprehensive trial at the Station and a few of the resulting lines are still extant after fifteen generations. But though the better lines were not significantly inferior to their parent variety, none was superior. In the next stage swedes of all types were intercrossed, and lines were bred from F_2-segregates, again by selfing. The combination of certain types was noted as worthless; from others, strains of good performance were obtained, and these were intensively selected to eradicate faults in appearance, but not always with success, for they had too often become fixed by inbreeding. Selfing, seeding in groups and recombination by hand crossing are all being used in an attempt to combine moderate uniformity, hybrid vigour and flexibility for further selection. Dry matter yield has been used as a guide to feeding value whenever possible; a self-imposed handicap, since this criterion is accorded little or no consideration by growers in this country. Selection by individual root tests proved of doubtful value, and the dry matter percentage of a plot of the progeny is preferable. Throughout this whole period efforts to obtain resistance to clubroot have continued, but all that can be said to date is that self-fertilisation does not appear to lead to the fixation of any resistance factors which may be carried by the swede, and that no other usable source of resistance has yet been found.

By the late 'thirties the progressive decline in the popularity of the swede directed attention to the kales, and some strains were selected and various intra-specific hybridisations made. However, in order to avoid contaminating the broccoli strains which were being bred during the war years, all large-scale propagation of kales ceased for a time and the few strains that it was found possible to maintain suffered loss of vigour as a result of inbreeding. The most promising of the surviving hybrids is a leafy form derived from thousand-headed kale × broccoli, and this mating has recently been repeated with other types of broccoli. The present aim is to seek new forms or types of fodder plant which might supplement or even supersede kale or rape while continuing with the swede, but on a less exclusive scale than hitherto.

Potatoes.—When the Scottish Plant Breeding Station was established, relatively little information was available regarding

the genetics and cytology of the potato and the potentialities of both wild and cultivated species in Central and South America had never been seriously investigated. Although the breeding of new varieties had been vigorously pursued, mainly by private breeders, since the middle of last century, much of it was essentially of an empirical nature. The potato was slow to become a subject for genetical research chiefly on account of its complex hybrid structure and the difficulties of genetic analysis associated with its polyploid constitution. Accordingly, the aims of the Society from its inception were twofold: first to carry out investigations calculated to yield scientific information concerning potatoes and potato breeding, and secondly to produce new and improved varieties of direct value to agriculture.

In the early years investigations were mostly concerned with studies of the inheritance of characters such as pigmentation in tubers and flowers, shape of tubers, depth of eyes and colour of flesh. These studies provided useful information and demonstrated the complexity of the hereditary constitution of commercial potato varieties as a whole. But it soon became clear that resistance to the many diseases and pests that attack the crop must form the basis of future work.

At that time, thanks to the activities of the Potato Synonym Committee and to the Potato Inspection Scheme of the Department of Agriculture for Scotland, potato growing in Scotland was in a highly organised state, varieties were accurately described and synonyms were practically non-existent. It was thus possible to assess accurately the merits and demerits of the varieties most widely grown and to determine the characters most urgently in need of attention. Immunity to wart disease, as a result of legislation, had become an essential quality for new varieties and breeding experiments were conducted to determine the nature of this immunity and its mode of inheritance. Fortunately, many of the popular varieties were immune to the disease, and, since the character was inherited in dominant fashion, it could readily be transmitted from generation to generation. Apart from wart disease, the most serious losses at that time were considered to be due to blight and to virus diseases.

The search for blight resistant varieties had been in progress in this country since the disastrous epidemics of 1845-46, but it was not until 1909 that resistance was demonstrated in wild

species by Dr Salaman at Cambridge. About the same time the late Dr Wilson in St Andrews employed the Mexican species *S. demissum* in breeding experiments, and later derivatives of that material were presented to the Society. In the course of subsequent field trials it was observed that certain selections bred from Dr Wilson's seedlings remained free from blight while adjoining plots succumbed to the disease. These selections provided the initial parent plants for the work on blight resistance which followed. A few years later, however, a new race of blight appeared which was capable of attacking Dr Wilson's seedlings although the wild species from which they had been bred was completely resistant. It was thus necessary to start afresh by hybridising *S. demissum* and selecting in subsequent back-cross generations for resistance to the new as well as the original race of the parasite. This work started in 1932, but it was found that progenies bred only from *S. demissum* and *S. tuberosum* gave segregation ratios which bore little resemblance to standard Mendelian ratios, due to the different chromosome numbers of the species and the irregularities in their behaviour. In order to overcome this difficulty, *S. demissum,* which is hexaploid, was crossed with the diploid species *S. rybinii* and a fertile tetraploid hybrid obtained. This hybrid in turn was crossed with *S. tuberosum* and the triple hybrids which resulted were back-crossed. Repeated back-crossing to *S. tuberosum* varieties then followed. Chromosome behaviour in these plants was normal and the segregation ratios obtained were comparable with Mendelian expectations.

As these experiments progressed and as more races of the parasite were isolated it became possible to distinguish the different types of resisters produced. The ultimate outcome of these studies has been the formulation of a scheme which provides a genetical basis for the classification of races of the fungus and the relationships so illustrated afforded a means of calculating the segregation ratios to be expected from the mating of any pair of genotypes in the series when infected with any race or group of races of the parasite. It has since been adopted as the international system for the nomenclature of races of blight (*P. infestans*) and of genes or hereditary factors controlling hypersensitivity in *S. demissum* derivatives.

The results obtained suggest that the four genes so far identified may prove inadequate for the permanent protection of varieties because a race of the parasite has been found which

is capable of attacking the combination of all four genes. It is apparent, however, from recent tests that *S. demissum* possesses additional genes and that certain other wild species also contain resistance genes effective against the known races of the parasite. Whether absolute immunity to the disease will ever be achieved is doubtful since no indications that the fungus has reached the limits of its variability have been obtained. On the other hand, resistance factors in wild species have only been partially explored and the available evidence indicates that at least a valuable degree of resistance will ultimately be obtained from that source.

The first blight resistant variety to be introduced by the Station was Craigs Snow White. This was in 1947 and it was followed in 1950 by Craigs van Riebeeck, a variety resistant to strains A, C and D and approved for cultivation in South Africa. The next of the series was Pentland Ace, a variety resistant to strains A, B, C and D which was registered in 1951 by the Department of Agriculture for Scotland.

The potato root eelworm (*Heterodera rostochiensis*) has been a menace to the crop for many years in some of the best potato-growing areas in the country. In more recent years, as a result of intensive potato cultivation during and after the Second World War, it reached serious proportions and was probably responsible for greater losses than any other single disease. No means of combating the pest by breeding methods was known until 1951 when Ellenby at Newcastle discovered that eelworm resistant forms did exist in the Commonwealth Potato Collection. The potentialities of this material were fully appreciated by the Agricultural Research Council and arrangements were made to initiate an intensive breeding programme. Selfed seeds of four eelworm resistant forms of *S. andigenum* were obtained from Cambridge in 1952 and selected plants raised from them were crossed with commercial varieties. Further breeding, using the back-cross system, was carried out without delay, with the result that large numbers of seedlings of the second back-cross generation are now being grown. Tests for resistance in most of the progenies were made by growing the plants in the open in an eelworm infested plot ; the remainder were grown in pots using heavily infested soil. The results of this work suggest that resistance may be controlled by three different mechanisms—viz., by a single dominant gene, by two complementary genes, or by multiple factors (polygenes).

The single dominant gene appears to offer the best prospects at the moment.

Although the nature of resistance has not been fully ascertained, it is clear that resistant plants can stimulate the emergence of larvæ in the same manner as susceptibles and that the invading larvæ are subsequently inhibited in the root at various stages of development prior to cyst formation. Under favourable conditions some resistant plants may even show an occasional poorly developed cyst, suggesting that inhibition, although adequate for practical purposes, is not always absolute. Probably the only danger that could be associated with such cysts is that incomplete inhibition may be the means of selecting out races of eelworm more virulent than the normal. These and other aspects of the problem are being investigated.

The prospects of producing commercially acceptable eelworm resistant varieties within a reasonable time are encouraging. The species *S. andigenum* is closely related to commercial varieties and no special obstacles to progressive breeding have so far been encountered. Attractive selections from first back-cross generations have already been made and some of them, in respect of yield and size of tuber, are comparable with commercial varieties.

As already indicated, the importance of virus diseases was early appreciated, but it was not until 1930 that the Society received, through the Department of Agriculture for Scotland, a grant from the Empire Marketing Board to enable work on these diseases to be started at the Station. The initial inquiry involved the possibilities that there were in potato varieties hereditary qualities of resistance which could be utilised in virus control. At that time there was little evidence of such resistance, and it was felt that the greatest chance of success lay in the development of varieties which were so tolerant of the diseases that they were little affected by them. This line of investigation was followed for some time, but as the danger inherent in breeding potential "carrier" varieties became manifest and, moreover, as acceptable forms of positive resistance were brought to light, interest in tolerance gradually waned.

In the case of mosaic diseases, a field of great promise was opened up with the discovery that many cultivated varieties are field immune to one or more of the viruses X, A, B and C.

On genetic analysis the character in respect of each virus was found to be controlled by a single hereditary factor and inherited as a Mendelian dominant. Also, the analyses showed that the two genes relating to viruses X and A are so firmly linked that by a suitable choice of parent they can be transferred together as almost a single unit. This is a fortunate linkage which has greatly facilitated breeding and advantage has been taken of it to such an extent that the majority of seedlings submitted by the Station to the Registration Trials in recent years have possessed the double field immunity, and four varieties of this type, Craigs Defiance, Craigs Royal, Craigs Snow White and Pentland Ace, have been registered by the Department of Agriculture for Scotland.

The discovery of field immunity to viruses X, A, B and C, led to a search for a similar response to virus Y. For this purpose the possibilities of the exotic material contained in the Commonwealth Potato Collection were explored. A gene controlling violent necrotic reaction to the virus was found in several sources, but in no case was the source material resistant to the virus. Attempts were made, therefore, to transfer this gene to a genetic environment in which its effect would lead to localisation of the virus at the site of infection. Ultimately, this was accomplished and several lines of parental material hypersensitive to virus Y have been synthesised for use in commercial breeding.

Although the initial objective of providing parental material resistant to all the *common* viruses causing mosaic diseases has been achieved, the use of field immune varieties must not be regarded as a permanent solution to the problem of virus control. The viruses concerned are themselves subject to change and the defence mechanism involved in field immunity may actually encourage the selection of specially adapted strains that break down varietal resistance. From studies on virus strains evidence has been obtained that this form of selection has taken place in the past and there is no reason to doubt that it may take place again in the future. Because of the potential breakdown in resistance, increasing attention is now being given to the study of immunity to X viruses shown by the seedling U.S.41956 and several clones of *Solanum acaule*, and to Y viruses by certain clones of *Solanum longipedicellatum*.

Resistance to the leaf-roll virus was first recognised in field

trials carried out during the period 1933-35. In these trials the varieties International Kidney, Shamrock and Southesk were outstanding in their ability to withstand infection and subsequent inheritance studies showed that their resistance is of a heritable nature. The factors concerned are, however, several in number and cumulative in their effect. The utilisation of these factors in practical breeding is, therefore, not a matter of direct application as the resistance tends to be dissipated by outbreeding. Nevertheless, by close breeding within a small number of resistant varieties and seedlings derived from them it has been possible to accumulate resistance factors in sufficient quantity to make them available for use in breeding for commercial purposes.

Sugar Beet.—As long ago as 1926 the Society was consulted as to the feasibility of breeding a strain of sugar beet to suit Scottish conditions, but as there seemed to be no immediate prospect of financial assistance forthcoming for such a project the matter was taken no further. It was not until after the Government had reorganised the industry in 1939, and had set up a Committee to administer a fund for sugar beet research, that the subject was again considered by the Society. In 1941 this Committee requested the Plant Breeding Institute, Cambridge, to study problems in relation to the maintenance and improvement of stocks of sugar beet then available in England. A study was made of the physiology of sugar beet and from this was developed the breeding of forms resistant to bolting. Six years later the Society was approached and undertook a programme which was financed by the Sugar Beet Research and Education Committee. The short-term object of this was to help the Cambridge breeders to advance a non-bolting strain to the market stage as quickly as possible. Cambridge breeding material, consisting of families and lines, was sown out at Corstorphine as early as practicable in the spring of 1948 and subsequent years. The observations on bolting were of chief importance, though sugar yields were assessed when possible. In addition selected roots were propagated in isolation plots, and plants of a number of families were seeded together in "polycross" plots to see how they would combine in an experimental strain. Unfortunately, outdoor propagation of sugar beet in the Edinburgh area has proved most unsatisfactory, few samples having the necessary vigour of germination for comparison with commercial seed. By 1953 the Cambridge

Institute had determined on a combination of families with sufficient merit to be passed on to the National Institute of Agricultural Botany for multiplication as a strain and for testing in large-scale trials.

Thus progress had been made towards reaching a solution to the first problem, and the part which the Scottish Plant Breeding Station should now play had to be reviewed. In the first place there is no finality about breeding a sugar beet strain, because elite stocks of the component families have to be kept up to standard and better families may be found and introduced. The Scottish Station has, therefore, continued to test samples sent from Cambridge. The breeding of a second strain suited to Scotland may or may not be economic, but the Station has been selecting families from sources unrelated to the Cambridge material since 1948, and aiming at a heavier foliage type in addition to freedom from bolting. The bad condition of much of the seed hampered this work and in the last few years some of the families have been propagated in England by courtesy of the Cambridge Plant Breeding Institute. The introduction of *male-sterility* and a *mono-germ* character into non-bolting sugar beet of a type suited to this country would be a useful achievement, and work of this nature is proceeding. Sugar beet is at present grown mainly in favourable districts and on fields chosen with care. A long-term policy would be to develop a type of beet which would give satisfactory crops both to the farmer and the factory when grown on upland farms and in other less favoured environments. If the answer should be a large-rooted, low-grade beet, a factory with a different process of sugar extraction might be needed, so there is little practical interest in this project meanwhile.

It will have been observed that in some Sections there has been little deviation from the original ideas while in others developments have taken place in previously unforeseen directions in response partly to the evolution of scientific thought and partly to altered agricultural needs. For instance, the middle 'thirties saw the milling oat come in for a greater share of attention than hitherto, and more recently there is evidence of another change in emphasis, for while the search for specialised varieties still goes on the demand for general purpose oats is apparently on the increase. Similarly the root

crops programme has had to take cognisance of changing agricultural conditions as they affect the popularity of the swede crop. The original emphasis as far as the herbage plant programme was concerned was on the needs of the arable farmer ; now pastoral farming comes into the picture and the programme has been extended to cover some of the problems associated with the improvement of natural grasslands. Moreover, the realisation that the genetical aspects of ecology had a particular bearing on the herbage plant work led to the development of a genecological department which is now a feature of the Herbage Plant Section. In potatoes the increasing menace of virus diseases resulted in the initiation in 1930 of a special programme devoted to the study of these diseases, and the bringing together a few years later of the Commonwealth Potato Collection gave a new impetus to potato breeding by providing virtually untapped reservoirs of genetic material. It is not surprising that in the original programme there is no mention of sugar beet, for it was not until the establishment of the Cupar factory in 1926 that sugar beet became a Scottish crop : now sugar beet has been added to the list of crops being studied at the Station.

To try to assess the value of a programme with objectives so broadly defined as " the promotion of agriculture " is no easy matter, for no single criterion can be regarded as the sole yardstick. The number of new varieties produced might have been taken as a convenient measure of achievement were it not for the fact that not all the activities of the Station have been directed to that end. For example, that part of the herbage programme which is devoted to the study of natural grassland is not at all, and the virus investigations only indirectly, concerned with the raising of marketable products. Nor should it be assumed that the observations made in the course of routine breeding work, whether successful or not, are devoid of significance to problems other than those of breeding. Indeed such information is not infrequently found to have a bearing on quite a number of agricultural questions, some of them only remotely associated with breeding. As an example of the way in which such " incidental " information can unobtrusively filter into practical agriculture it may be mentioned that the Station has contributed, if only in a small way, to the solution of some of the problems which from time to time have faced the Plant Registration Station when formulating their projects

relating to the maintenance of virus tested potato stocks, herbage plant nomenclature, grass strain testing and oat certification.

This brief survey of the development of the work of the Station over a period of more than thirty years well illustrates the wisdom of the Founders in stating the objectives of the Society in the most general terms. It is hoped that the same flexibility of policy and outlook that has characterised the programme thus far will continue into the future.

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